SUNY POLYTECHNIC INSTITUTE

CATN2 Center for Advanced Technology in Nanomaterials and Nanoelectronics

SUNY Polytechnic Institute's Zero Energy Net (ZEN) Test-Bed Assets

Zero Energy Net (ZEN) Test-bed

Perceived risk by the design engineering (DE) community associated with the integration of innovative "passive" and "active" clean energy (CE) measures have emerged as a significant obstacle to wide-scale adoption of energy efficient "Zero Energy Buildings" (ZEB). Compounding this challenge is the need to incorporate, adapt and develop new data models, analyses, and control platforms by the data science (DS) community that can measure technical and financial viability while providing real-time operational control. Success increasingly requires open-innovation to enable: multi-discipline collaboration, multi-system integration, and multi-use applications. Access to real world test-beds are increasingly viewed as critical to success with demonstration of technical validation by identifying Key Technology Indicators (KTIs) and financial validation by determining Cost-of-Ownership (COO) and Return-on-Investment (ROI).

The Zero Energy Net (ZEN) test-bed is the largest zero energy multi-use facility in the world with over 356,000 ft.^{2} and costing $205 million to construct including investments of $14M in passive and $16M of active CE measures. First conceived in 2012 with construction completed in 2015, ZEN was designed and built as a mission critical "smart building" that includes a 30,000 sf^2 Tier-3 data center with maximum demand load of 4 megawatt (MW). ZEN generates, captures and analyzes data from over 3,000 data points allowing for analysis of active CE technologies and passive CE design measures with the capability to operate in a smart grid environment. With a translucent ETFE-pillow roofed central atrium allowing passive solar light to the core of the building floor plates, ZEN is truly a "living laboratory" that is constantly reacting to a changing Northeastern climate where each technology and design measure contributes to achieving the goal of net zero energy as measured over a year rather than at any single moment in time.

ZEN was conceived, designed and built with a goal to demonstrate a new model that combines: open-innovation collaboration among multi-discipline partners; open-access data platforms to integrate multi-

system CE measures; and, open-source networks to address multi-use applications. This novel approach included the formation of a public-private partnership to burden-share the construction of the ZEN test-bed that is now generating the performance data necessary to determine technical viability and the cost data to determine financial viability. The PPP model also enables a pathway to scale the adoption by: 1) driving integration of data modeling and control platforms by engaging DE & DS firms; 2) supporting workforce training of facility operation personnel with real-world hands-on learning; and, 3) enabling commercialization of innovative CE solutions.

ZEN's open-innovation collaboration among multi-discipline partners including engineers, architects, data scientists, clean energy experts, construction managers, and the building owner that utilized Building Integrated Modeling (BIM) to evaluate a wide range of "passive" energy design measures (dynamic & static) and "active" CE technologies (efficiency, storage & generation) with each contributing as the building reacts to changing Northeast climate conditions. The result was not only a state-of-the-art test-bed, but also aligned an eco-system of global leaders in design engineering (DE) including: EYP-US, Exyte-Germany, DPS-Ireland, CHA-US, Shimizu-Japan and SSOE-US; data science (DS) including: IEEE/Global Spec, Commerce Hub, NYS ITS, General Control Systems; and, smart building (SB) agencies including: NYPA, NYSERDA, NEDO-Japan. NEDO administered a multi-prong investment in clean energy technologies on behalf of Japanese technology companies including Shimizu Corporation (BEMS), Seiko (personal RFID tags), Fuji Electric (fuel cell), Solar Frontier (PV), Tachikawa Trading (gradation blinds), among others. These investments have continued to provide the CATN2 with unique energy test bed capabilities and resulted in on-going data collection and analysis, synchronization testing with traditional Caterpillar back-up power testing, requiring upgrade in power conditioning equipment and test-bed testing.

ZEN's open access data platform utilizes a GE iFIX and GE Proficy Historian for data storage as a custom designed Building Management System (BMS), that tracks over 3,000 data points related to the operational performance of the various components, equipment and systems (CES) that operate the ZEN facility. The ZEN facility also utilizes a Schneider "Power SCADA Expert" with "Power Monitoring Expert for Data Centers" (aka ExoStructure) and Historian data storage as the Energy Monitoring System (EMS) that tracks an additional 1,500 data points related to energy load monitors of the same CES. Both systems have been configured as a "flow-of-data" as a "digital twin" for real time monitoring and control, with historical endogenous and exogenous data accessible as a "data warehouse" for a broad array of modeling, AI, machine learning, scenario analysis among other uses. Data is collected from on-site (internal) systems including market-ready facility operation systems (entropy wheel and heat recovery from data center operations, power switching, security, etc.) and emerging CE measures as well as off-site (external) sources including net-metered PV production sites, complimentary CE test-beds, weather, energy pricing among other external data sources.

ZEN's open-source networks target multi-use applications including next generation CE components and systems, mission critical data center operation, network operation centers, smart grid/micro-grid operation, and advanced manufacturing facility operations. CE components and systems represent individual market sector opportunities including heat recovery technology (harvesting) for a 4MW, 30,000 sf^2 tier-3 data center located on the first floor; smart window blinds (cooling & glare); occupant RFID tracking (ergonometric measurement); high efficiency lighting; motion detecting, safety, & security sensors (security); a 100 kW phosphoric acid fuel cell & back-up generator synchronization (resiliency), photovoltaic (generation), and among many others. ZEN's passive design measures include solar luminance control sensors to optimize a translucent ETFE-pillow roof, high efficiency window glazing, plug load controls, high efficiency envelope, building orientation, among many others.